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EFFECT OF MICROWAVES ON THE IMMUNE SYSTEM.(U)  
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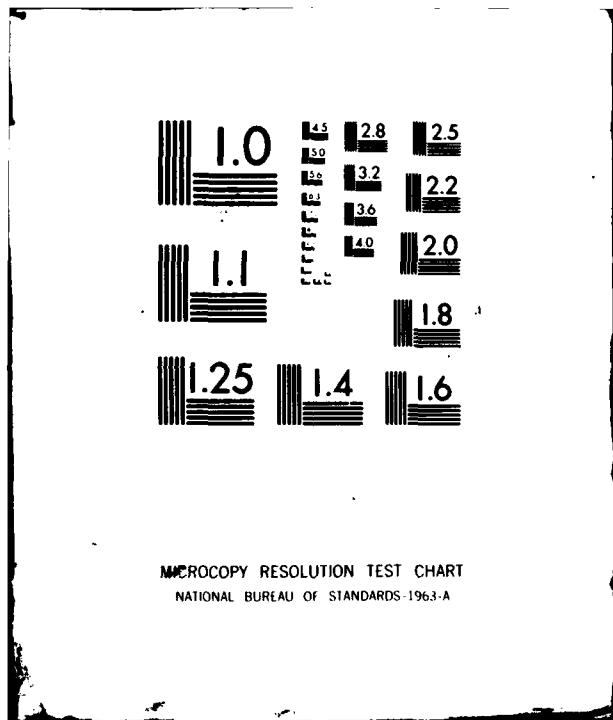
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Microwave irradiation is an increasingly important environmental factor for both military and civilian populations. Because of numerous practical applications of MW, its use is widespread. Despite its immune system. Over the past year, we have been involved in evaluating particular reference to lymphocyte bearing complement receptors (CR <sup>+</sup> ). Initial studies established threshold requirements for changing the frequency of CR <sup>+</sup> spleen cells with respect to intensity, wave length, duration and cumulative effect using a mouse model. Further, genetic factors were found to play a role in predisposin			

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these animals to the effects of MW.

We have this year expanded the observations of the MW effect on CR<sup>+</sup> cells, initiated studies of other cells of the immune system and begun to genetically map these effects.

In addition to the observed effect on CR<sup>+</sup> cells of the spleen as we previously observed, we have now established CR<sup>+</sup> cells increased in peripheral blood and lymphoid organs, but not in bone marrow cells. During the course of these investigations, it has been found that a number of other cell populations besides those carrying complement receptors are affected by MW exposure. For example, cells bearing Fc receptors are increased, natural killer cells are increased, and myeloid progenitor cells are affected by exposure to MW.

Genetic studies indicate that susceptibility to the inductive increase in splenic CR<sup>+</sup> cells, following exposure to 2450 MHz MW, is under the control of a gene or genes closely associated with the major histocompatibility complex (H-2) of the mouse. All responsive strains of mice tested were of the H-2<sup>k</sup> type. Preliminary data indicates that the essential genes are outside the classical H-2 gene segment, but are unable to differentiate whether the genes controlling susceptibility to MW are located near or far from the H-2 complex.

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OFFICE OF NAVAL RESEARCH  
CONTRACT N000-14-78-C-0278

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FINAL REPORT

20 MARCH 1980

EFFECT OF MICROWAVES ON THE IMMUNE SYSTEM

By

Philip L. Calcagno, M.D.

K. Sulek, M.D. and

W.W. Jedrzejczak

Immunologic Oncology Division

Division of Pediatrics

Georgetown University School of Medicine

3900 Reservoir Rd., N.W.

Washington, D.C. 20007

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## EFFECT OF MICROWAVES ON THE IMMUNE SYSTEM

ONR CONTRACT N000-14-78-C-0278

### 1. BACKGROUND

Microwave irradiation is an increasingly important environmental factor for both military and civilian populations. Due to the widespread use of this radiation source, it is essential to determine the possible effects of this type of radiation on various biological systems. One such biological system is the immune system, and evidence has begun to accumulate over the past decade that microwave exposure may produce effects on the immune system. The physiological importance of the immune system lies in its key role in defense against bacterial, mycotic, and viral infections, as well as our defense against malignant tumors. Cells of the immune system recognize and eliminate foreign bodies in either a nonspecific manner, or one that is specific (related to the precise chemically defined structure). Impairment of the function of these immune cells may lead to decreased sensitivity to various infectious agents, and malignancies.

Over the past two decades, one of the major advances in biology has been the study of the requirement for cellular interactions in the immune response, and the development of cell markers enabling researchers to detect the maturational events occurring as the cells of the hematopoietic system differentiate from the primordial stem cells, to the well differentiated, functional cells, representing the end point of the maturational scheme. During the past few years the study of cellular maturation, and functional capabilities of cells, has vastly expanded, both in the area of animal and human physiology. In the mouse system, in particular, great strides have been made in methods to evaluate the activity of stem cells, as well as functional

cells along the various lines maturation. It was the purpose of this contract to evaluate changes in various immune cell populations upon exposure to microwave irradiation.

## 2. SUMMARY OF RESEARCH ACTIVITIES

Over the past 2 years we have been involved in evaluating the effects of microwaves on various populations of immune cells with particular reference to lymphocytes bearing complement receptors (CR<sup>+</sup>). In our previous observations, we have shown that microwave exposure increases the frequency of CR<sup>+</sup> spleen cells in exposed mice, as compared to shams. We have been able to determine the threshold exposure conditions necessary to induce these changes, and have found that multiple subthreshold doses induce a similar effect, if the exposures are close together. We have also found that genetic factors play an important role in predisposing animals for the positive responses, and studies to map the specific genes are in progress.

In attempting to elucidate the possible mechanisms for the observed increases in CR<sup>+</sup> cells, our data indicates that these are not mediated via endotoxin, or corticosteroids, as has been suggested by others.

In addition to the observed effect on splenic lymphocytes, CR<sup>+</sup> cells are increased in peripheral blood, and lymphoid organs, but not bone marrow cells. During the course of these investigations, it has been found that a number of other cell populations besides those carrying complement receptors are affected by microwave exposure. For example cells bearing Fc receptors are increased, natural killer cells are increased, and myeloid progenitor cells are effected by exposure to microwaves.

### 3. MAJOR ACCOMPLISHMENTS OF RESEARCH

During the course of these investigations we have been able to establish the following:

1. A single 30 min. exposure of CBA/J mice to 2450 MHz at 0.6W forward power produces a significant increase in CR<sup>+</sup> spleen cells most pronounced on the 6th day after exposure, then gradually decreasing to pre-exposure levels over several days.
2. The lower threshold time of exposure to the frequency 2450 MHz is 15 min., and the upper threshold is approximately 45 min. A longer time of exposure doesn't produce a greater effect on the 3rd, 6th or 9th day after exposure.
3. The angle of exposure has no significant effect on the results obtained.
4. Exposure to MW increases the percentage of CR<sup>+</sup> spleen cells only when CBA/J mice are 6 weeks of age or more, suggesting that susceptible precursor cells must be present.
5. When repeated 3 or 6 times, exposures at subthreshold exposure times have a cumulative effect.
6. The absolute number of spleen cells does not increase following MW.
7. Mice of varying genetic background are not uniformly susceptible to the effects of MW as determined by the % increase in CR<sup>+</sup> cells, i.e., ALB/c mice show no increase in CR<sup>+</sup> cells following standard exposure while CBA/J mice do.
8. Genes that control the increase in CR<sup>+</sup> cells in response to microwave exposure are associated with but outside of the H-2 complex on the 17th chromosome of the mouse.
9. Microwave exposure increases the level of natural killer (NK) cells. Possibly by inducing interferon production, however the mechanism of these observations is unknown.

#### 4. CONCLUSIONS OF RESEARCH

It is clear the animals exposed to small doses of microwave irradiation exhibit changes in their immune cells. The increases in complement receptor bearing cells and natural killer cells are statistically significant. The mechanisms by which these changes occur is unknown.

#### 5. INDEX OF TECHNICAL REPORTS

DOCUMENT	SUBMISSION DATE
Status Report No. 1	December 1978
Technical Report No. 1	September 1979
Status Report No. 2	December 1979
Final Technical Report	March 1980

#### 6. INDEX OF PUBLICATIONS AND ABSTRACTS

##### PUBLICATIONS

K. Sulek, C.J. Schlagel, W. Wiktor-Jedrzejczak, H.S. Ho, W.M. Leach, A. Ahmed, J.N. Woody. Biologic effects of microwave exposure. I. Threshold conditions of the increase in complement receptor positive (CR<sup>+</sup>) mouse spleen cells following exposure to 2450 MHz microwaves. (Accepted for publication in Radiation Research).

C.J. Schlagel, K. Sulek, H.S. Ho., W.M. Leach, A. Ahmed, J.N. Woody. Biologic effects of microwave exposure. II. Studies on the genetic control of susceptibility to microwave induced increases in complement receptor positive (CR<sup>+</sup>) mouse spleen cells following exposure to 2450 MHz microwaves. (Submitted for publication) Bioelectromagnetics.

C.J. Schlagel, K. Sulek, A. Ahmed, H. Ho, W. Leach. Kinetics and mechanisms of the induction of an increase in complement receptor positive (CR<sup>+</sup>) mouse spleen cells following a single exposure to 2450 MHz microwaves. URSI Bioelectromagnetic Symp. Seattle, 1979, Abstract. P. 478.

C.J. Schlagel, T. Folks, K. Sulek. Induction of natural killer cells in neonatal mice following exposure to 2450 MHz microwaves. (Manuscript in preparation).

#### ABSTRACTS

K. Sulek, A. Ahmed, C. Schlagel, W. Wiktor-Jedrzejczak, H. Ho, W.M. Leach. Microwave radiation and immune response. 4th FDA Science Symp. Proc. (in press).

C.J. Schlagel, T. Folks, J.N. Woody, W.M. Leach, K. Sulek. Enhancement of natural killer cell activity in mice after exposure to microwave radiation. FASEB Annual Meeting, Dallas 1979, Fed. Proc., 38, Abstract 3625 (1979).